# ROCKS ... and how to identify them

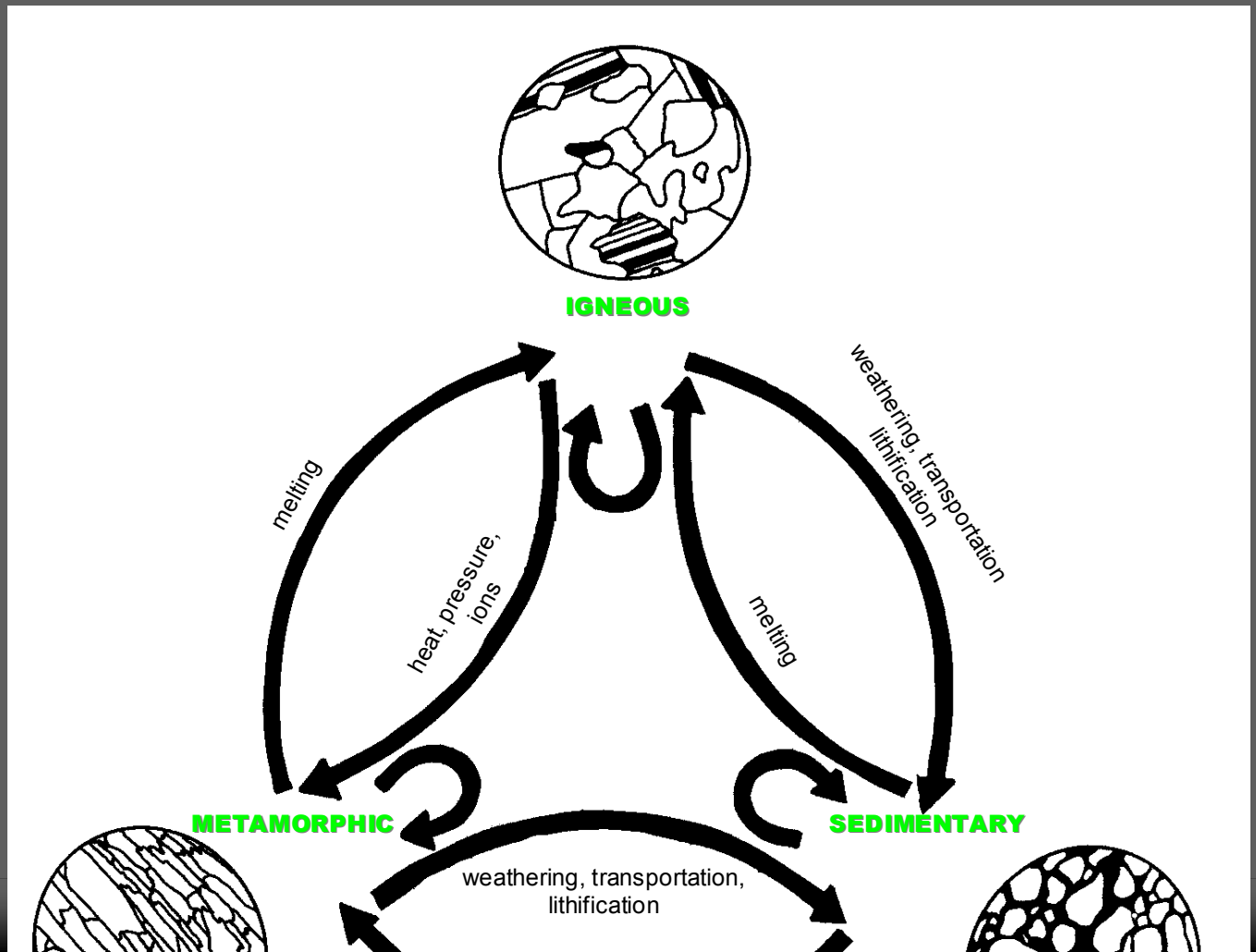
Arizona Historical Society

# THE ROCK CYCLE

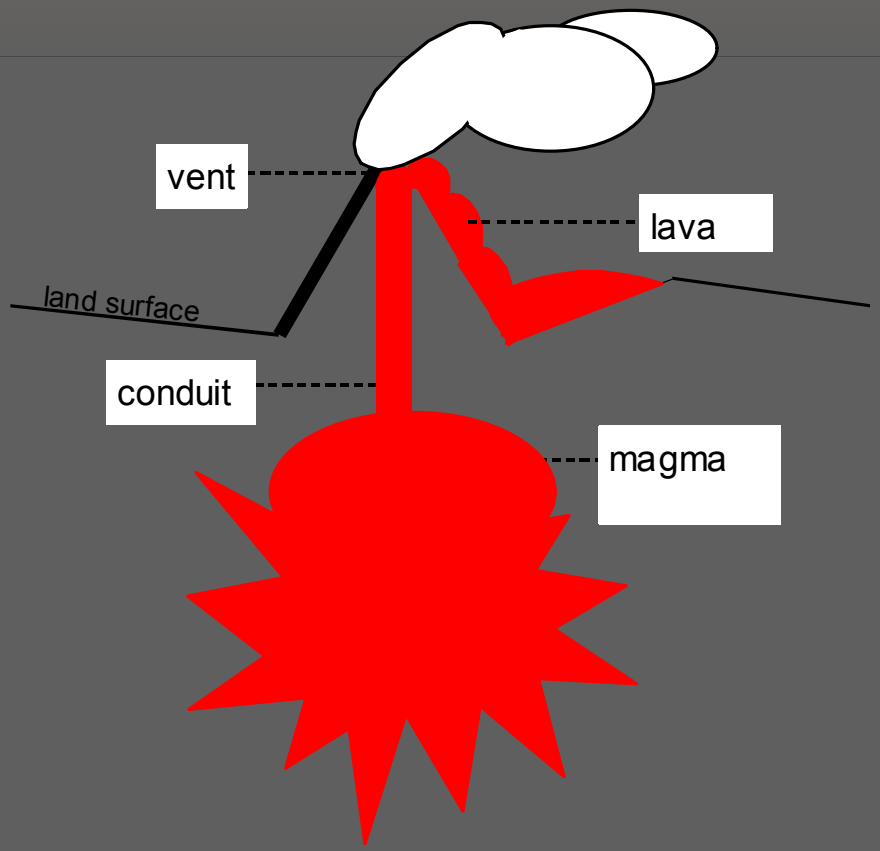
Rocks are naturally occurring combinations or coherent aggregates of minerals, fossils or other hard materials. They are classified by the way in which they form. The three rock types are: igneous, sedimentary and metamorphic.

All rocks on Earth are locked into a system of cycling and re-cycling known as the *ROCK CYCLE*.

# THE ROCK CYCLE



# IGNEOUS ROCKS




Anat omy of a Vol cano

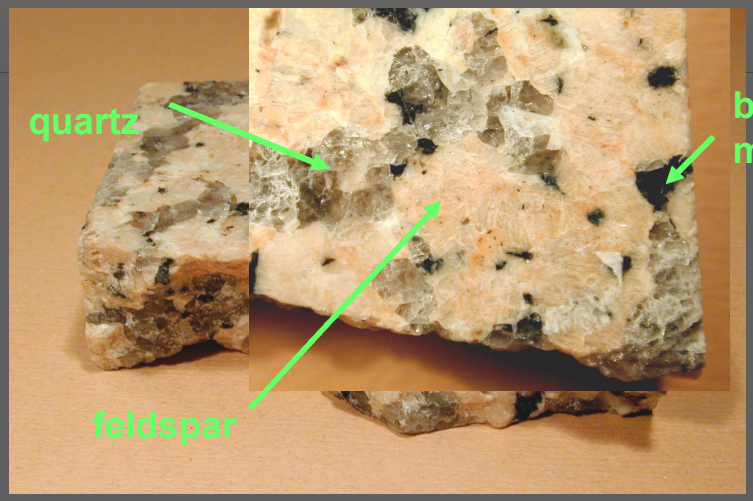
IGNEOUS ROCKS are “born of fire”. In other words, they were once molten and upon cooling, the **magma** (molten rock) crystallized into solid rock. Igneous rocks may form deep inside the Earth or at the Earth’s surface when a volcano erupts.

# IGNEOUS ROCKS

Slow cooling deep beneath the Earth's surface allows crystals to grow to large size (1/8" or more). These crystals are easily visible and distinguish this group of igneous rocks as **INTRUSIVE**.

Rapid cooling near or at the Earth's surface, produces many small crystals that are not readily seen by the unaided eye. This group of igneous rocks is called **EXTRUSIVE** and are typically volcanic in origin. Cooling may be so rapid that crystals do not have a chance to form and instead a glass is produced.

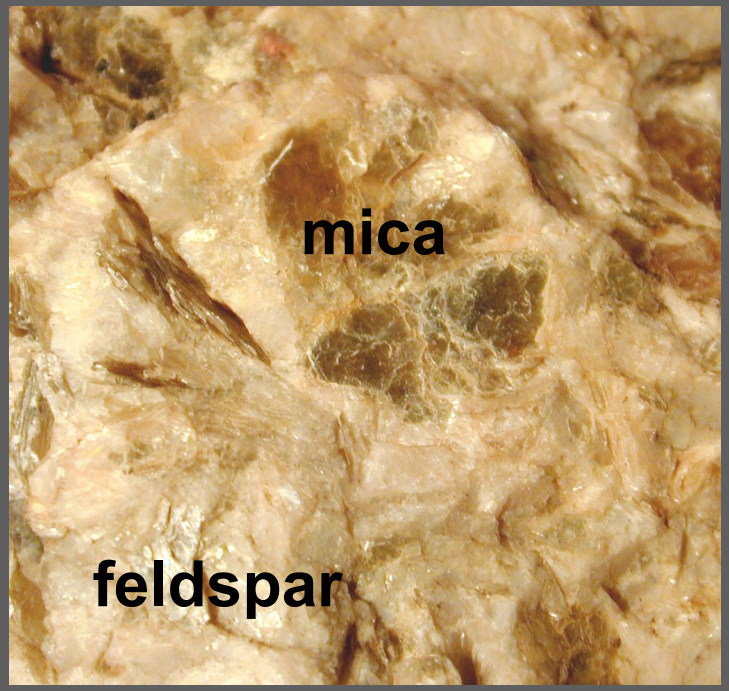
# Granite - intrusive




**GRANITE** is a coarse to medium-grained rock that forms from the cooling of magma deep within the Earth (*intrusive*). It is made up mainly of varying amounts of the minerals: quartz, orthoclase, muscovite, biotite and hornblende. The name is from the Latin *granum, for "grains".*

# Granite - intrusive

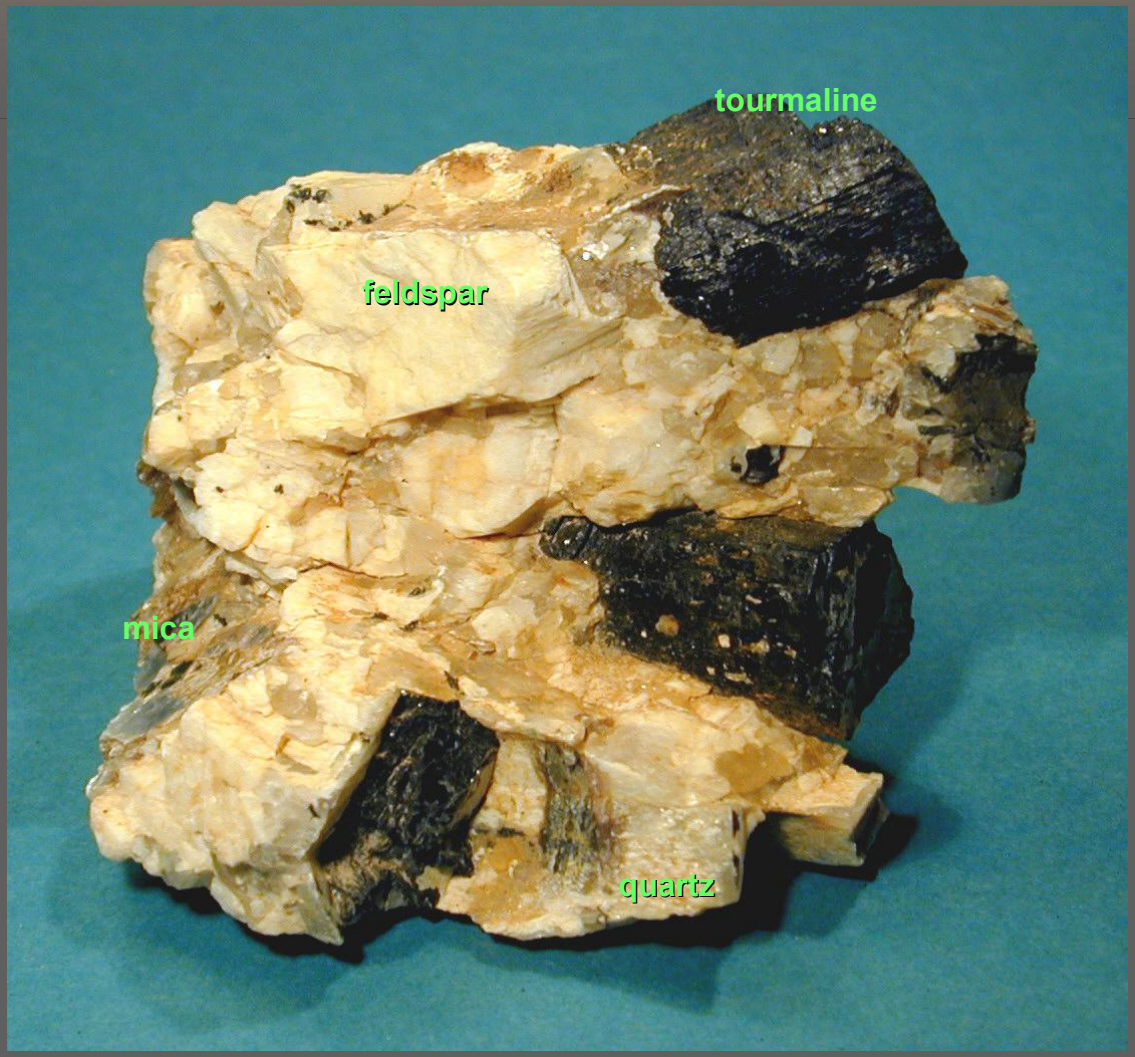

Porphyritic




Pegmatite

# Granite - intrusive

## Pegmatite a Special Case

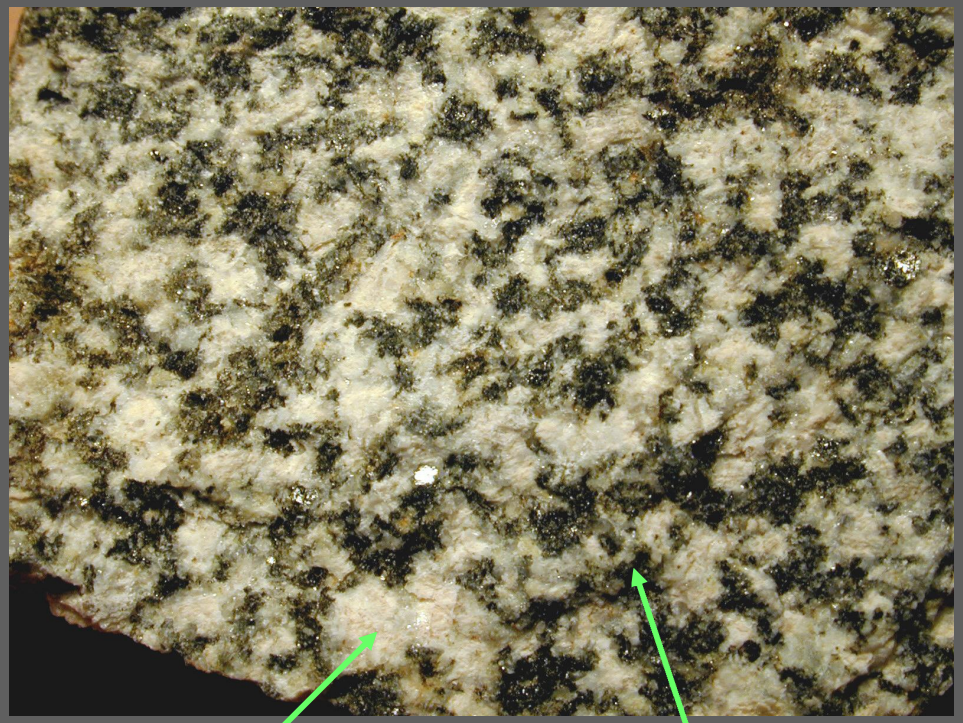



**PEGMATITES** are classified as intrusive igneous rocks, but there is a difference. They are VERY coarse grained and strictly speaking are not crystallizing out of a magma.

The coarse grained nature is the result of crystal growth in aqueous solutions rather than in the molten liquid state.

The resulting freedom of ion motion allows the crystal to grow much larger in a shorter length of time.

# Diorite - intrusive




**DIORITE** is very similar to granite, but is distinguished in the hand specimen by the absence of visible quartz.

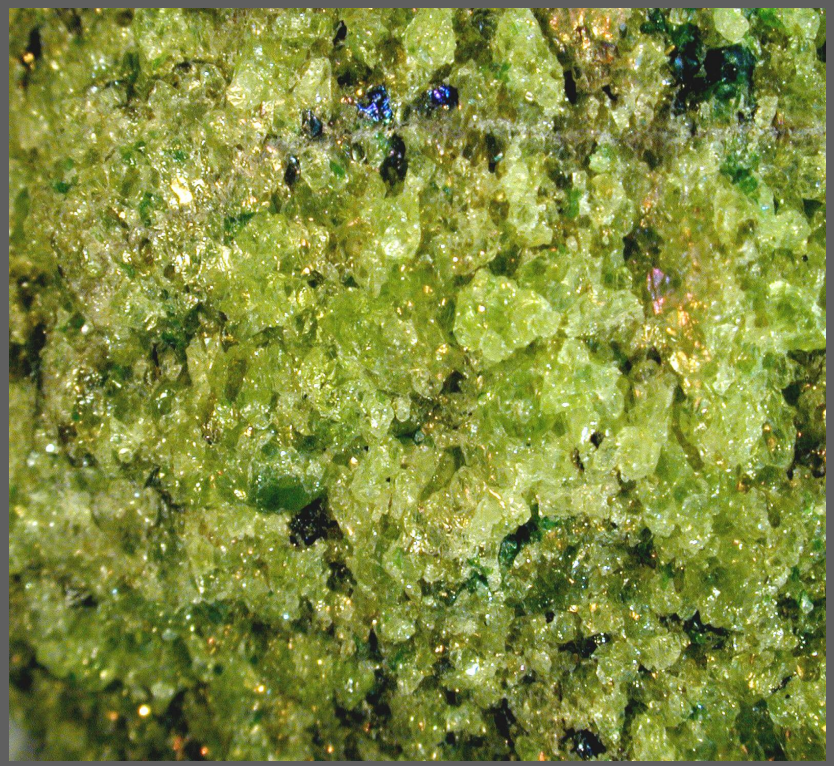
Generally it has a salt and pepper appearance (about ½ black and ½ white).

# Gabbro - intrusive

Black minerals are primarily amphibole (like hornblende) and plagioclase feldspar.

**GABBRO** is a coarse-grained rock that is high is iron & magnesium-bearing minerals (pyroxenes, amphiboles, plagioclase feldspar, olivene). The rocks will be dark in color, somewhat heavier than granitic rocks and devoid of quartz.

# Peridotite - intrusive



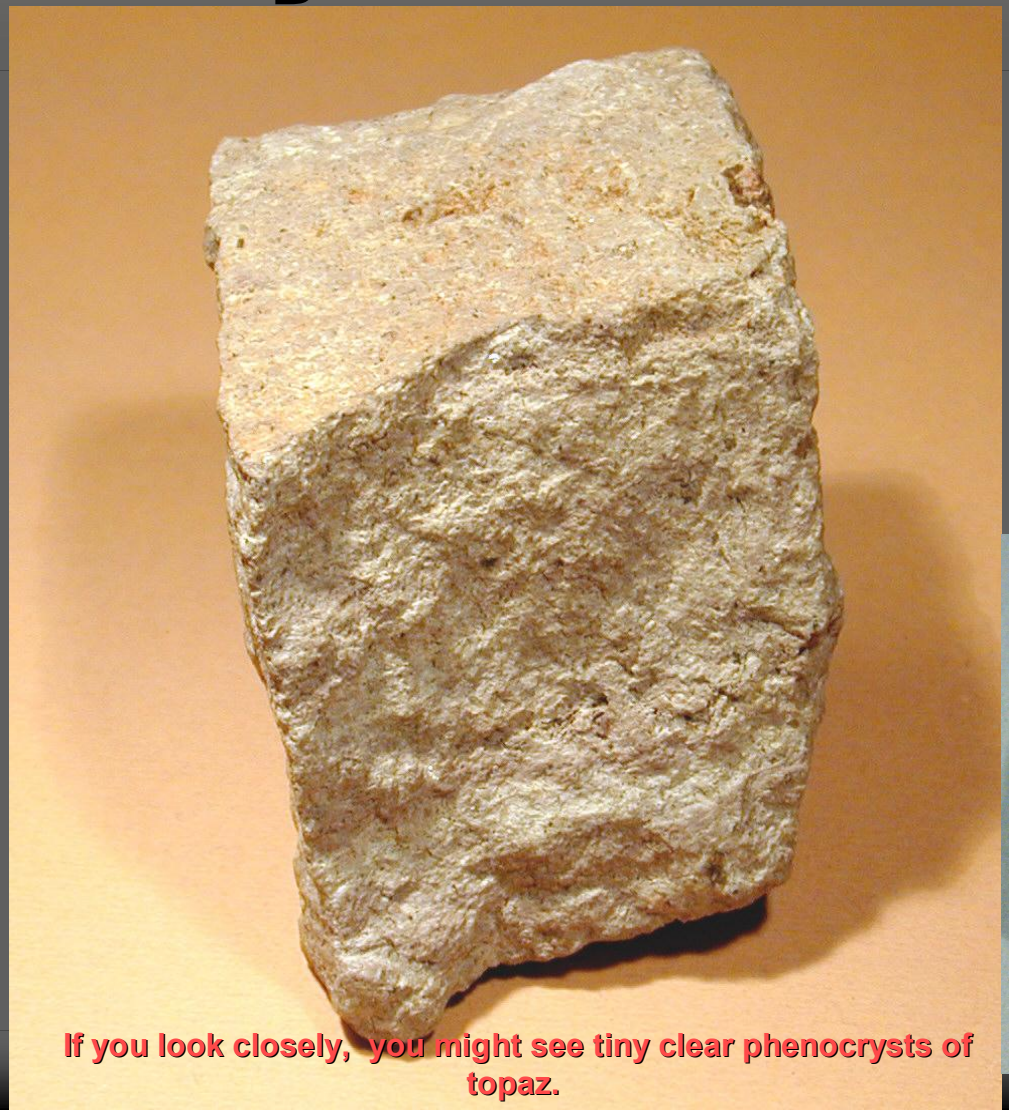
**PERIDOTITE** or DUNITE is composed of 90-100% olivine. As a result it is characteristically olive-greens in color.

This material is thought to have originated in the upper mantle of the Earth.

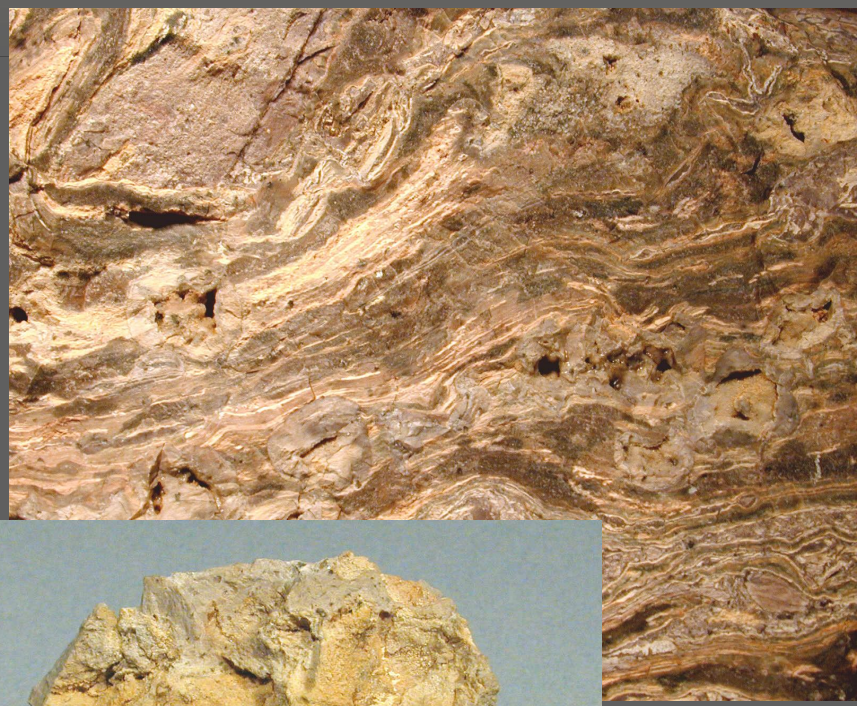
# Rhyolite – extrusive

**RHYOLITE**'S name comes from the Greek *rhyo*, from *rhyax*, "stream of lava". It is formed when molten rock with the same composition as a high silica granite oozes (rhyolite is VERY viscous and does not really flow) to the Earth's surface; and therefore cools quickly so only microscopic-sized crystals develop. The volcanoes that produce rhyolite are very explosive varieties such as Mt. St. Helens, Krakatoa and O'Leary Peak (AZ). Frequently it is banded due to flow alignment of different associated minerals (quartz, feldspar, mica, and hornblende).

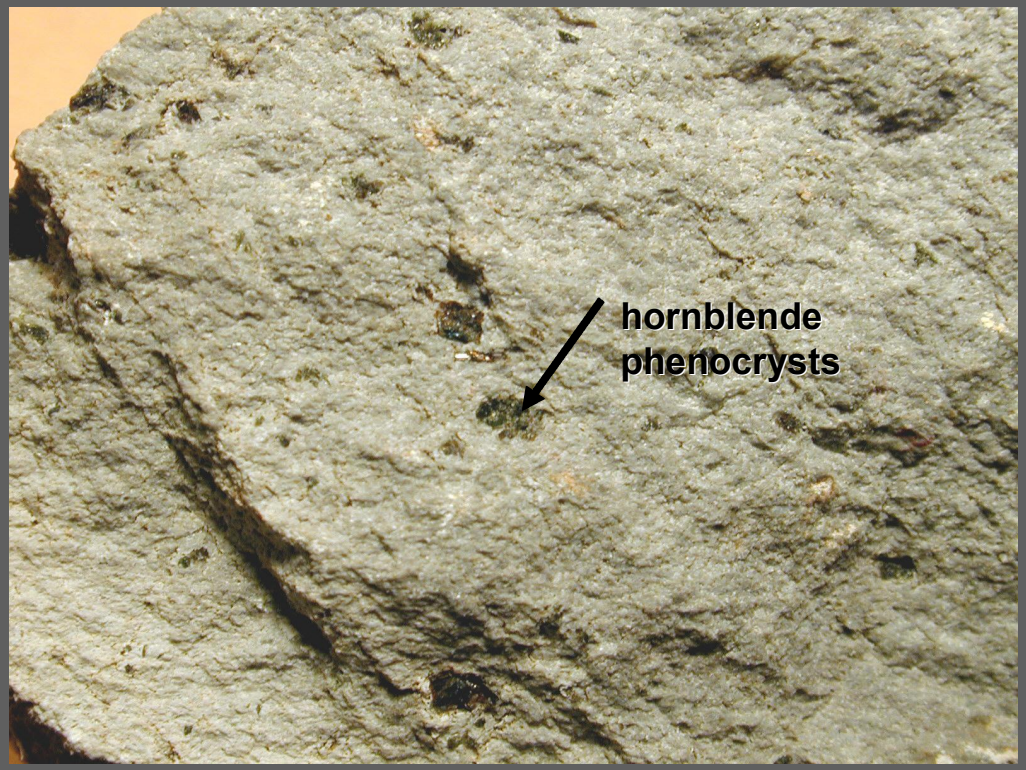
# Rhyolite – extrusive



If you look closely, you might see tiny clear phenocrysts of topaz.



# Andesite - extrusive




**ANDESITE** is the fine-grained equivalent of DIORITE. It tends to be a darker gray than rhyolite and is often porphyritic, with visible hornblende.

# Basalt - extrusive

**BASALT** occurs as thin to massive lava. flows, sometimes accumulating to thicknesses of thousands of feet and covering thousands of square miles. The volcanoes that produce basaltic lavas are relatively quiet, such as the Hawaiian Islands volcanoes. Basalt is dark, fine-grained and often *vesicular* (having gas pockets). The pockets may be filled with secondary minerals, e.g. quartz, zeolite minerals, calcite, opal, etc. and then it is called *amygdaloidal* (a-mig-duh-*loy*-dal) basalt.

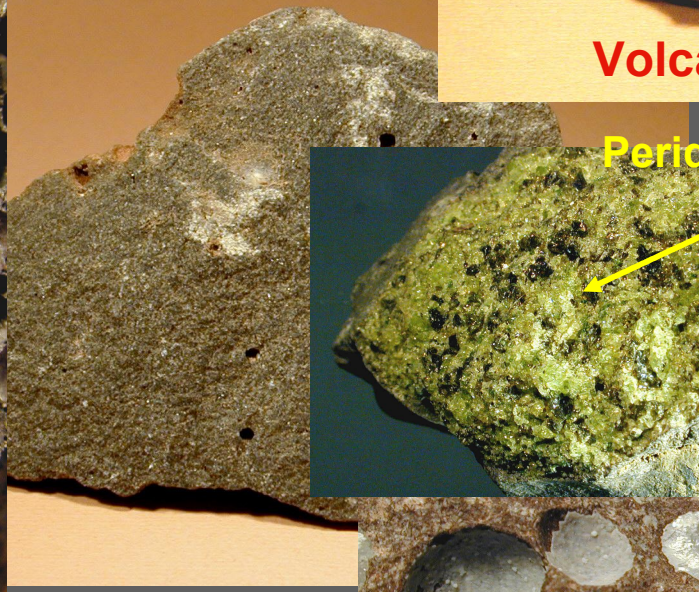
The name may have originated with Pliny who used the Ethiopian word *basal* for iron-bearing rocks.

# Basalt - extrusive

Vesicular (Scoria)

Gases released near the surface of a lava flow create bubbles or ***vesicles*** that are "frozen" in stone

Volcanic Bomb





Peridotite xenolith

Basalt

Amygdaloidal

# Basalt - extrusive

Pahoehoe is a feature that forms on the surface of very fluid basalt flows. Much like the skin on a bowl of tomato soup – the surface in contact with the air begins to crystallize, while the fluid lava below continues to flow. This drags the upper, still plastic, surface into a series of smooth wrinkles.

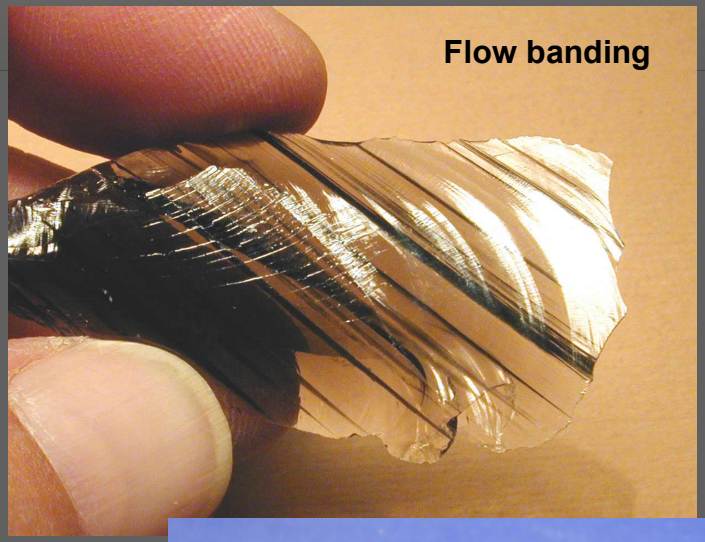
# Obsidian - extrusive

**OBSIDIAN** is volcanic glass (an acrystalline "solid" –actually a supercooled liquid). Its glassy, lustrous and sometimes banded appearance makes it rather easy to distinguish from all other rocks. It is composed of the elements that make quartz, feldspar and iron/ magnesium minerals that have cooled so quickly that the minerals could not develop and crystallize.

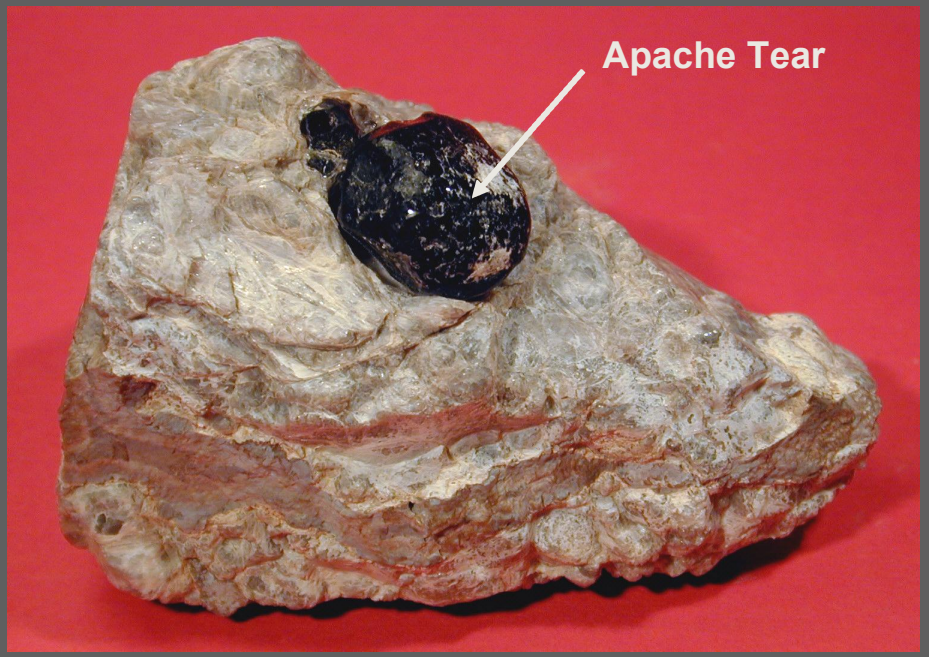
Colors vary from black to red, black & red (mahogany), gray, green, iridescent, snowflake.

Apache Tears are little nodules of obsidian.

# Obsidian - extrusive

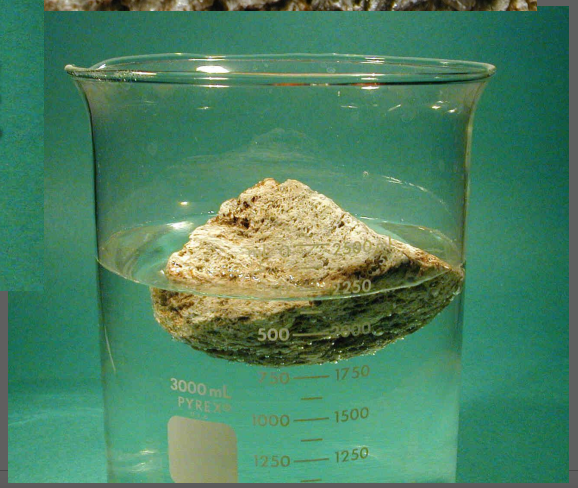

# Perlite - extrusive




**PERLITE** is a light gray volcanic glass, having numerous concentric cracks which give rise to a perlitic or onion skin structure. It is generally of rhyolitic composition. It also exhibits a *pearly luster.*

Apache Tears are some times found embedded in perlite.

# Pumice - extrusive




**PUMICE** is highly vesicular (i.e. it has lots of gas bubble holes) and is of rhyolitic composition.

Due to the many small holes, it is lightweight and will often float in water.

# Tuff - extrusive

**Tuff** is the accumulation of ash and small pyroclastic debris (<4mm). Thick beds may form for many miles around a very explosive volcano, such as Mt. St. Helens.

Often, when the material is still hot upon deposition, it welds into a very hard rock.

# Volcanic Breccia - extrusive

**VOLCANIC BRECCIA** is pyroclastic (fire-formed fragments) and forms in explosive eruptions. It is a mix of large angular fragments and small ash.

Often, the material is hot when it comes to rest and cools (welds) into a very hard rock.

# SEDIMENTARY ROCKS

SEDIMENTARY ROCKS are composed of particles derived from pre-existing rocks or by the crystallization of minerals that were held in solutions. A general characteristic of this group is the layering or *stratification*, as seen in the outcrop.

Those sedimentary rocks that are composed of particles of pre-existing rocks are considered **FRAGMENTAL** or **CLASTIC**. These fragments show evidence of transport – rounding of the grains and size sorting.

**CHEMICAL** sedimentary rocks are the result of either precipitation of solids from solutions (like salt from water) or by organic process, like shells from marine organisms.

# CLUES TO SEDIMENTARY ROCKS

FRAGMENTAL: Composed of pieces of rocks and minerals

| | |
|---|---|
| LARGE PIECES (Boulders,cobbles, pebbles) | **BRECCIA:** Composed of large angular pieces and clay<br>**CONGLOMERATE:** Composed of large rounded pieces and clay |
| SMALL PIECES (sand) | **SANDSTONE:** Looks sandy (may "shed" sand grains), feels rough (like sandpaper); may be tan, white, red, gray. |
| VERY SMALL PIECES (clay, silt, mud) | **SHALE:** Has very thin layers; often black. May have fossils — usually impressions (no shell, but indentation with pattern of shell) or carbonized film (as for plants). Has a dull luster. Is soft. When tapped with a rod or on a table, it generally makes a dull thunk. |

# Breccia - fragmental

A **BRECCIA** is made of varying sizes of *angular* fragments cemented together. The name is from the Italian word for “broken stones” or “rubble”.

Many form as the result of fault movement; others form as the result of rapid and short transportation, such as landslides.

# Conglomerate - fragmental

**CONGLOMERATES** are very similar to breccias, but the fragments are *rounded*. The name is from the Latin *conglomeratus* for "heaped, rolled or pressed together".

These rocks form in alluvial fans, stream beds and pebble beaches.

# Sandstone - fragmental

**SANDSTONE** is made up of fine-grained particles (1/16 – 2 mm). The sand grains (often quartz) are commonly cemented by silica, carbonates, clay or iron oxides. Sandstone is identified by its sandy texture – which often translates into a gritty feel.

Environments in which sandstones form include beaches, sand bars, deltas and dunes.

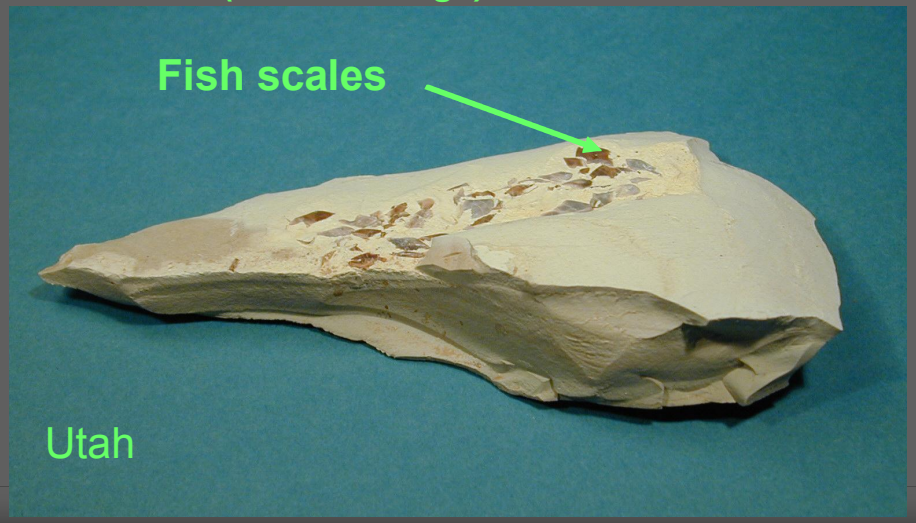
**Coconino Sandstone, the result of a Permian age coastal dune field**

# Shale - fragmental

**SHALE** is a very common rock made of silt and clay sized particles. It is generally very thin-bedded and splits along the bedding planes. In fact, the name is probably from the Old English *scealu*, "shell or husk". Normally gray to black, shale may be brown to dark red, depending on the amount of included iron oxide.

Shales form in quiet environments, such as lakes, swamps, deltas and offshore marine.

**Black shale, deposited in a offshore basin in a Middle Cambrian sea. Wheeler Shale with trilobite fossil (*Elrathia kingii*)**



# *MORE CLUES TO SEDIMENTARY ROCKS*

CHEMICAL: Rocks are crystalline

**LIMESTONES:** Composed of calcite and all WILL FIZZ vigorously in acid
- Crystalline — Looks sugary, usually gray or tan
- Fossiliferous — Contains seashells (usually) or other aquatic organisms
- Travertine — Looks sugary with bands of various colors
- Chalk — White and soft (comes off on hands)
- Coquina — Contains almost nothing but seashells or seashell fragments

**CHERT:** **Cryptocrystalline QUARTZ**
- Very fine — can NOT see crystals
- Waxy luster
- Conchoidal fracture (breaks like glass)
- Very hard — will easily scratch glass
- May be ANY COLOR (Red = Jasper, Black = Flint, includes Silicified Wood)

**GYPSUM:** White, gray, clear
- Very soft — you can scratch with fingernail
- Clear sheets, fibrous or sugary

**ROCK SALT:** White to clear — cubic shape
- Soft — you can scratch it with fingernail
- Tastes like table salt (IT IS TABLE SALT!)

**COAL:** Black; Brittle; Lightweight
- May contain plant fossils
- Varieties: peat, lignite (incl. jet), sub-bituminous, bituminous

**DIATOMITE:** White
- Very soft (comes off on your hands)
- Lightweight
- Will NOT fizz in HCl acid (unlike chalk)

# Limestone - chemical

**LIMESTONE** is composed primarily of calcite. Generally it is dense, fine-grained, and usually white to dark gray. Its most distinguishing feature is its solubility in weak hydrochloric or acetic acid accompanied by brisk effervescence.

The environment of deposition if generally warm, shallow seas. Therefore, marine invertebrate fossils are common.

Uses:

- **Manufacture of lime and Portland cement & to neutralize smokestack gases.**
- **Finely ground, used as a functional filler in products such as paint, countertops & plastics.**
- **The dust on chewing gum is ground limestone.**
- **Mild abrasive additive to toothpaste.**
- **Soil conditioner**
- **Flux in processing iron and copper ores.**
- **Building and ornamental stone.**

# LIMESTONE - chemical

## Crystalline

Redwall Limestone

## Coquina

Pleistocene, Rocky Point, Mexico


## Fossiliferous

# CHERT - chemical

**CHERT** is crypto-crystalline quartz. It is often the result of the dissolution of volcanic ash and is sometimes found in extensive beds, such as the novaculite of Arkansas.

It has waxy luster, is translucent and fractures conchoidally. Chert can be any color, but extensive beds are generally white to gray.

# GYPSUM - chemical





**GYPSUM** (calcium sulfate) is found in geographically wide-spread deposits resulting from the evaporation of a body of water, such as ocean basin or playa lake.

It is soft (H=2) & usually white to gray. Three varieties are: Alabaster, Satin Spar and Selenite.

Gypsum is mined for use in wallboard and plasters, as an agricultural amendment and to control the set/cure time of Portland cement.

# ROCK SALT - chemical

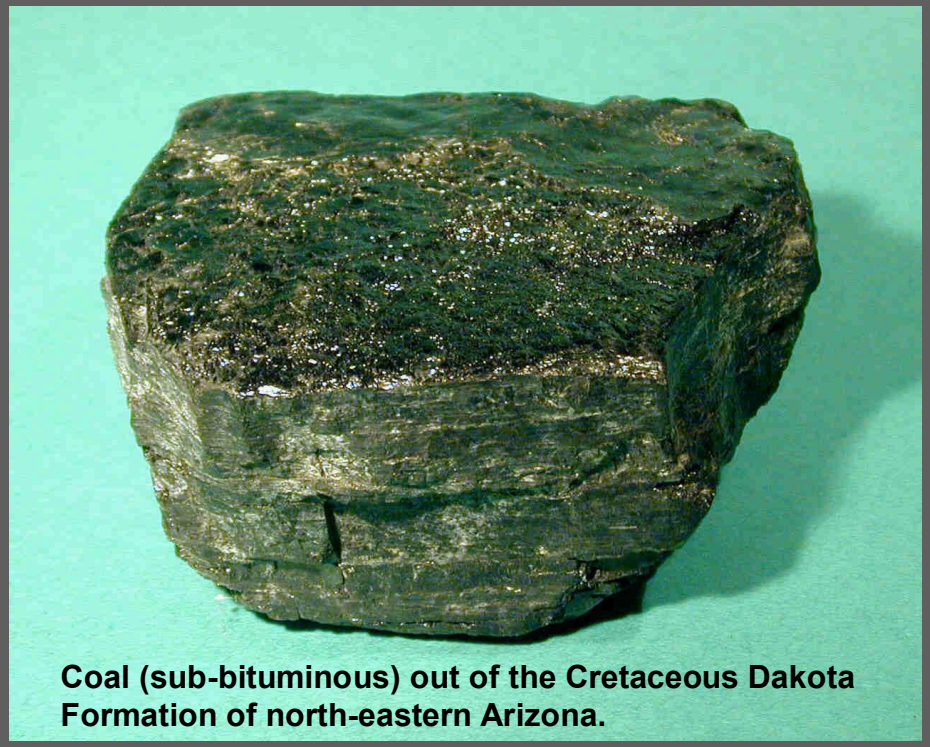

Halite Trona, CA

**ROCK SALT** (halite – sodium chloride) is also a deposit resulting from evaporation of a marine basin or playa lake.

It has cubic cleavage and tastes salty.

Rock salt is used as a source of chlorine and sodium, as a food supplement, in water softeners and as a road de-icer.

# COAL - chemical



Coal (sub-bituminous) out of the Cretaceous Dakota Formation of north-eastern Arizona.

COAL is considered a rock, although it is not composed of minerals, but rather the decomposed remains of large volumes of vegetation that accumulated in a wet, low oxygen environment, such as a swamp or marsh.

Peat, Lignite and Sub-Bituminous & Bituminous are sedimentary varieties of coal and are used as fuels.

# DIATOMITE - chemical


San Manuel, AZ

**DIATOMITE**, also known as diatomaceous earth, is composed of the siliceous shells of microscopic alga called diatoms. It is light weight and is generally white.

Diatomite is used as an abrasive, insecticide, filtering medium, and paint “flattener”.

# METAMORPHIC ROCKS

METAMORPHIC ROCKS have changed (*meta*) their form (*morphic*). Under the influence of heat, pressure and fluids, pre-existing rocks are modified in form and even in internal atomic structure to produce new rocks stable at the new conditions. This is done within the solid state, i.e. *without melting*.

Changes that occur include: increase in grain size, new minerals and foliation (parallel alignments).

Metamorphic rocks that exhibit parallel alignments of minerals are called FOLIATED. In these rocks, the minerals all line up perpendicular to the exerted pressure.

Metamorphic rocks composed of minerals that are not elongated or flat, do not exhibit parallel alignments and are called NON-FOLIATED.

# *CLUES TO METAMORPHIC ROCKS*

FOLIATED: Rocks have layers or banding

**SLATE:** Rock breaks into very thin layers
Beginning to look polished; Is harder than shale
Cannot see crystals
Black , gray or red

**PHYLLITE:** Like slate, but shinier ("phyllitic sheen" — similar to satin)

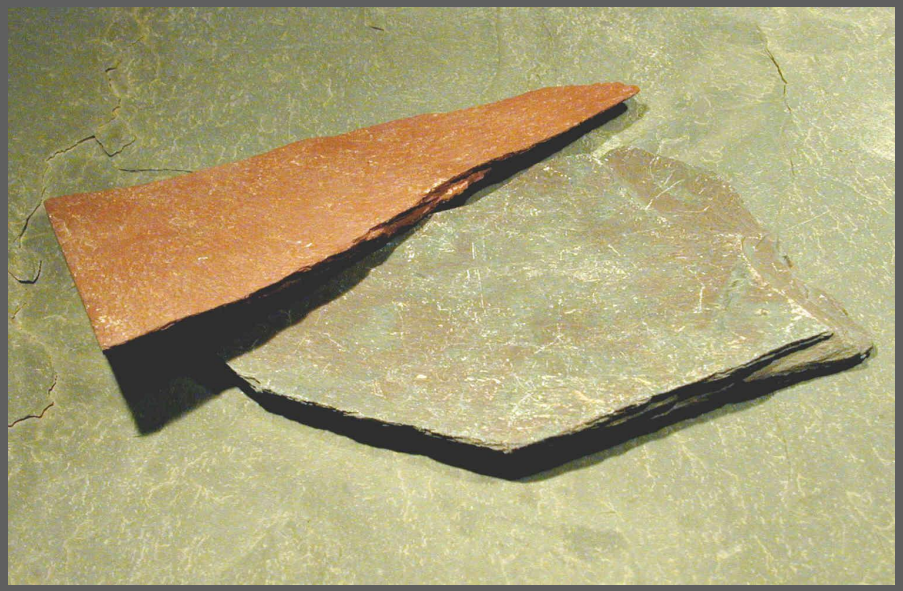
**SCHIST:** Very shiny — you can SEE CRYSTALS (usually MICA)
Is layered
May have crystals (of garnet, tourmaline, etc.) growing with the mica

**GNEISS:** Crystalline
Black & White BANDING (due to segregation of minerals)

# SLATE - foliated

SLATE is derived from shale. It is a dense, microcrystalline rock, but one in which parallel planes are very evident in its slaty foliation – a feature resulting from the alignment of clay and mica minerals,which allows it to split readily into sheets. It may be gray, black, green or red.

Uses include roofing, flagstone, pool table tops and "blackboards".



Note the relatively dull luster of slate.

# PHYLLITE - foliated

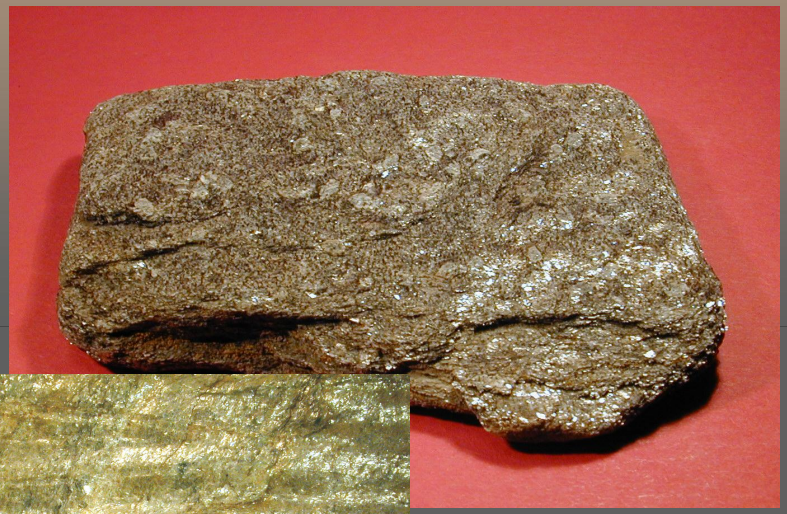
**PHYLLITE** is somewhat more metamorphosed than slate. The platy crystals of mica have grown and the rock displays a subtle, satiny shine referred to as *"phyllitic sheen".* The name comes from its leaf-like (many fine layers) appearance.

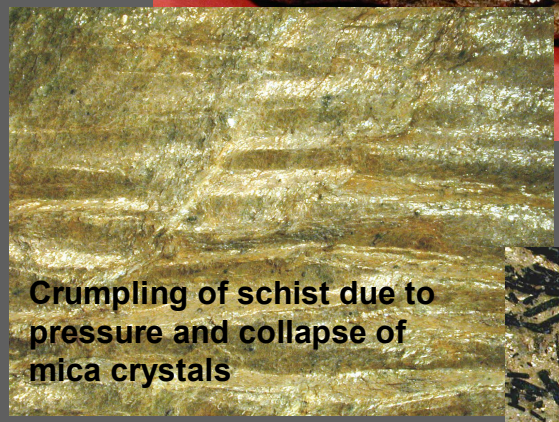
Note the phyllitic sheen.

# SCHIST - foliated

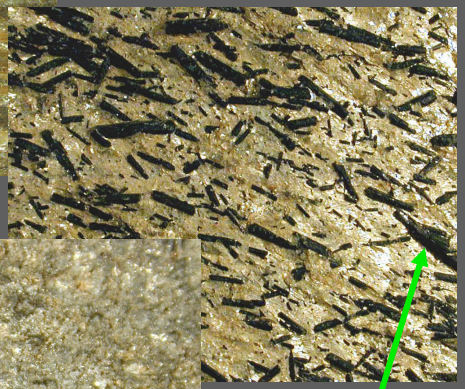
**SCHIST** is medium to coarse-grained, crystalline, with prominent parallel mineral orientation. Typically, it is predominately muscovite mica, which lends a silvery white to gray sparkly appearance. It is not unusual for accessory minerals (such as garnets, staurolite, tourmaline) to grow in the rock.

Schist is added to clay mixtures as a strengthening material in vitreous pipe (red sewer) and clay roof tiles.





Crumpling of schist due to pressure and collapse of mica crystals



tourmaline porphyroblast – note alignment

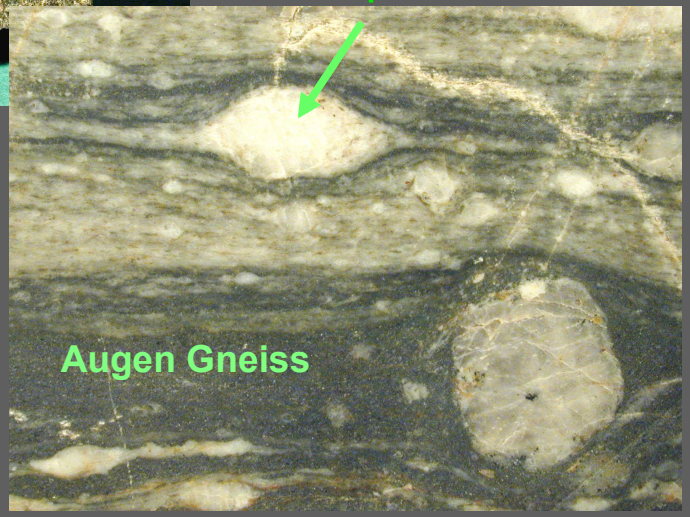
garnet porphyroblast

# GNEISS - foliated

GNEISS formed under conditions of high temperatures and pressures at great depth during regional metamorphism. It is characterized by foliation expressed as black and white banding. Because the rock becomes plastic, the banding is often contorted (squiggly).

Gneissic granite – separation of dark & light minerals is just beginning

Well banded gneiss



Augen = quartz pebble resistant to compression

Augen Gneiss

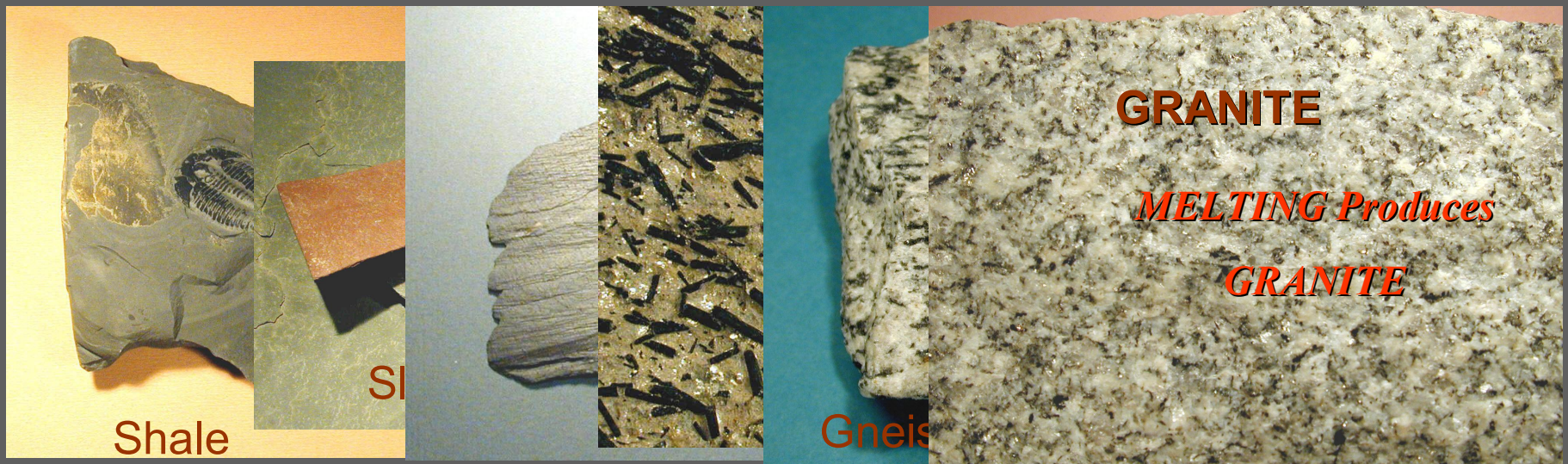
kink in gneiss

# metamorphism of shale

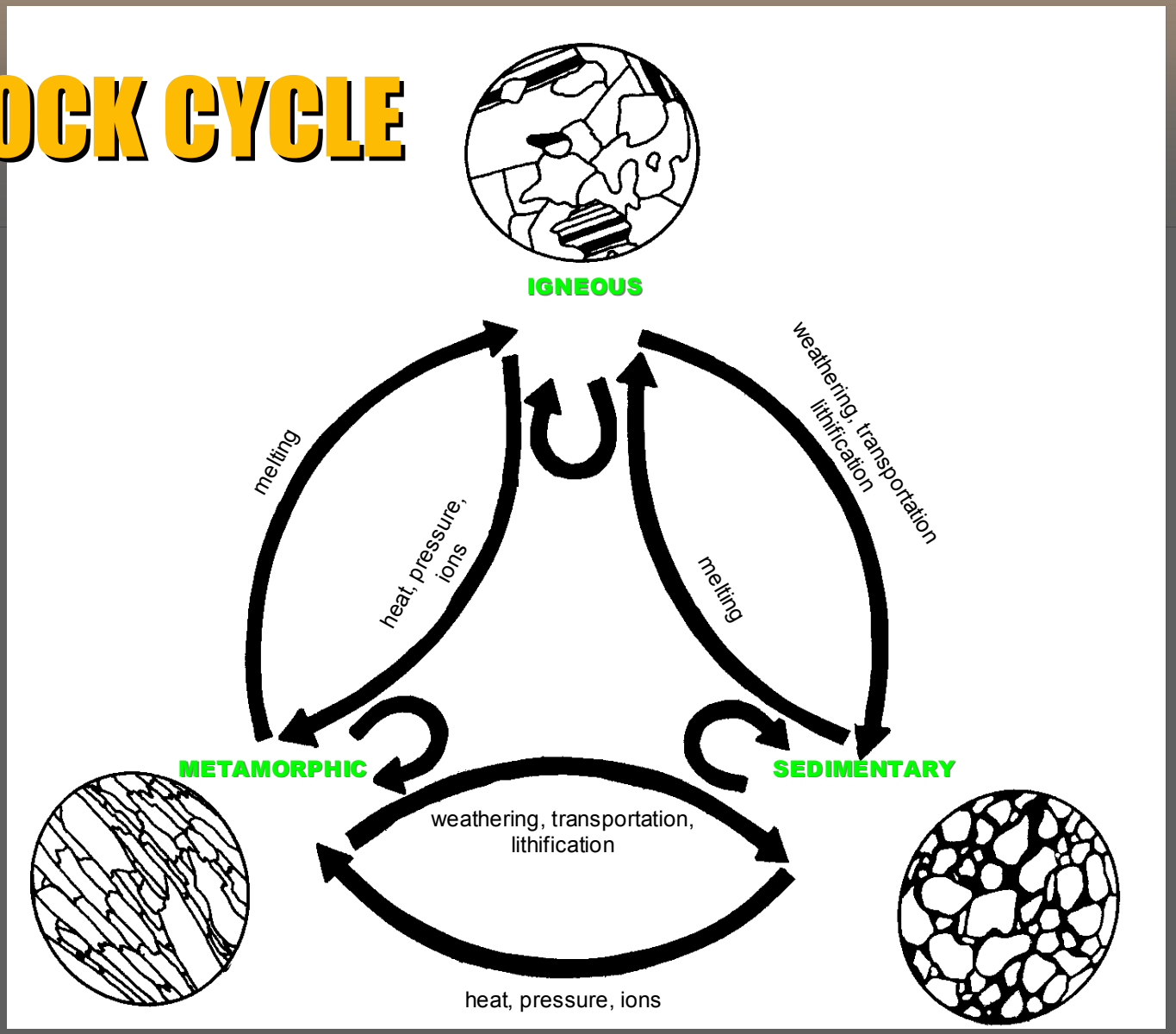
SHALE is the most common sedimentary rock.

Through the agents of metamorphism it changes to rocks that are stable at higher temperatures and pressures.

These changes take place in the solid state.



# THE ROCK CYCLE



# *CLUES TO METAMORPHIC ROCKS*

NON-FOLIATED: Shows NO layers or banding

**MARBLE:** Sugary looking
Will fizz in HCl (acid)
Often is multi-colored, may be white
Soft — will not scratch glass

**QUARTZITE:** Very dense
MAY look a bit sandy
Very hard — will easily scratch glass

**METACONGLOMERATE:** Looks like sedimentary conglomerate, BUT it is harder (BREAKS THROUGH PEBBLES) and often the pebbles are squished & aligned (it is at this point foliated)

**SERPENTINITE:** Composed of members of the serpentine family (includes chrysotile asbestos)
Generally light greenish gray to greenish black
Waxy luster
Often exhibit curved and slickensided surfaces

# MARBLE – non-foliated



**MARBLE** is metamorphosed limestone or dolomite. The colors can vary from pure white to gray, green, yellow, brown, black, red or any combination thereof, depending on the 'impurities' in the parent limestone. Bands or streaks result from plastic flow during extreme deformation, due to high pressure and temperature.

It is calcite or dolomite and will fizz in weak acids.

Marble is used for building facades, floors, countertops, statuary, landscaping, paving/roofing, poultry grit, and as filler/extender for paint, plastics, paper and adhesives.

# QUARTZITE – non-foliated

**QUARTZITE** is metamorphosed quartz sandstone. It is a very dense,durable, massive, microcrystalline rock (but still may retain a slightly sandy look). It can be any color, but tends to be white, tan or pink.

# SERPENTINITE – non-foliated


**SERPENTINITE** is composed of one or more minerals in the serpentine family. It is common where wet basalts or mantle rocks are metamorphosed, such as at convergent boundaries.

Its green colors, waxy luster, often associated asbestos and common slickensided surfaces are clues to its identity.

# METACONGLOMERATE – non-foliated


**METACONGLOMERATE** is metamorphosed conglomerate. It retains its pebbly appearance, but while a sedimentary conglomerate will break around the pebbles, a metaconglomerate will break through the pebbles.

If temperatures are high enough in the presence of pressure, the pebbles may become squished or flattened and will be elongated parallel to each other (becomes foliated).